U. S. DEPARTMENT OF COMMERCE

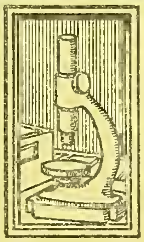
BUILDING MATERIALS AND STRUCTURES

REPORT BMS4

Accelerated Aging of Fiber Building Boards

by DANIEL A. JESSUP
SAMUEL G. WEISSBERG
and CHARLES G. WEBER

NATIONAL BUREAU OF STANDARDS



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The National Bureau of Standards is a fact-finding organization; it does not "approve" any particular material or method of construction. The technical findings in this series of reports are to be construed accordingly.

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Foreword

Vegetable Fiber Boards, a relatively new class of products, have some very desirable properties, but there is little published information as to how well the original properties are retained when in use. It is obviously not practicable to wait for the results of normal aging over a long period of years, yet some information as to the durability of these materials is needed before it can be determined whether it is good economy to substitute them for more costly materials in low-cost house construction.

This is a progress report, describing accelerated aging tests based on the results of the Bureau's experience in the use of similar tests on paper and other cellulosic materials. Some typical test data are included. The results obtained so far show that some of the boards have excellent stability, while a few lose certain desirable properties rather rapidly under the accelerated test. It is expected that this work will finally result in a performance specification and test method which will make possible the selection of material that is most likely to prove satisfactory.

Lyman J. Briggs, *Director.*

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ABSTRACT

Fiber Building Boards are being tested to determine whether they have satisfactory permanence to justify their wide use in low-cost house construction. Accelerated aging is being used because this information is urgently needed, inasmuch as it would take years to obtain the effects of normal aging. The aging treatments include cycles of wetting, drying, freezing, and heating in dry air, and the stability is judged by changes in physical and chemical properties. The properties most affected by aging are water absorption, nail-holding power, flexural strength, and permeability to air. Results thus far obtained are favorable. After being subjected to the aging cycles for a total of 300 hours, only two of the boards tested showed serious loss of strength and other desirable properties, despite the drastic nature of the treatments.

I. INTRODUCTION

For a Number of Years the National Bureau of Standards has made many studies of building materials to determine their physical properties as related to their performance in service. Supplementing its regular studies the Bureau is now engaged in a program of research to determine the properties and suitability of building materials with particular reference to their use in low-cost housing.[1] The durability of materials is one of the problems included in this work, and this report describes the accelerated aging procedure and tests developed by the Paper Section of the Bureau to determine the durability of fiber building boards.

Fiber building boards are sheet materials designed particularly for use in house construction, and are made in forms and sizes adapted for that purpose. They are made in sizes that can be rapidly and economically applied with a minimum of skilled labor. The boards are made resistant to moisture by the use of rosin, asphalt, waxes, or other sizings and coatings. There are three general uses for them in house construction: as heat-insulating components in walls and roofs; as sheathing under brick, stone veneer, or clapboards; and as finish for walls and ceilings.

The ordinary properties of the boards are well known. Data on wall boards and insulating boards are contained in two previous publications [2] [3] by members of the staff of the National Bureau of Standards. So far as the original values of the strength, insulation, water resistance, density, and rigidity are concerned, the boards have been found to be satisfactory. However, little is known as to the retention of these suitable properties under conditions of use. The boards are made of ground wood, or crudely refined fibers from wood or other vegetable growths. The pulping and refining of the fibers are not carried far enough to remove the lignins and gums naturally present in the plant, nor are the fibers bleached. Papers made of fibers in this

[1] The purpose of the housing investigation and scope of the problems assigned to the National Bureau of Standards are described in the first report of this series, Hugh L. Dryden, Research on Building Materials and Structures for use in Low-Cost Housing; Building Materials and Structures (1938) NBS Rep BMS1. Price 10 cents, stamps not accepted.

[2] Misc. Pub. BS 132 (1931).

[3] Ind. Eng. Chem. 27, 896 (1935).

unpurified condition have frequently been found to be unstable and to deteriorate rapidly. Therefore, even though the materials when new may have desirable properties which make them suitable for use in low-cost house construction, the question of how well these desirable properties are retained under conditions of use must be answered before the economy of substituting them for more costly materials of known stability can be justified.

Obviously, the most conclusive data on the permanence of the materials in service could be obtained from field and laboratory observations after years of service. However, the impracticability of waiting years for the results of such a procedure is apparent. Hence, use must be made of the alternative method of judging the performance on the basis of data obtained by accelerated aging. The materials are subjected to conditions which produce in a short time in the laboratory effects similar to those arising from long periods of natural aging. These conditions must be, of necessity, much more drastic than the deteriorating conditions encountered in use, in order to achieve results in a comparatively short time. However, they are qualitatively similar, and experience with paper and some other materials has shown that a high order of stability to accelerated aging means satisfactory permanence, while low stability to accelerated aging means unsatisfactory permanence.

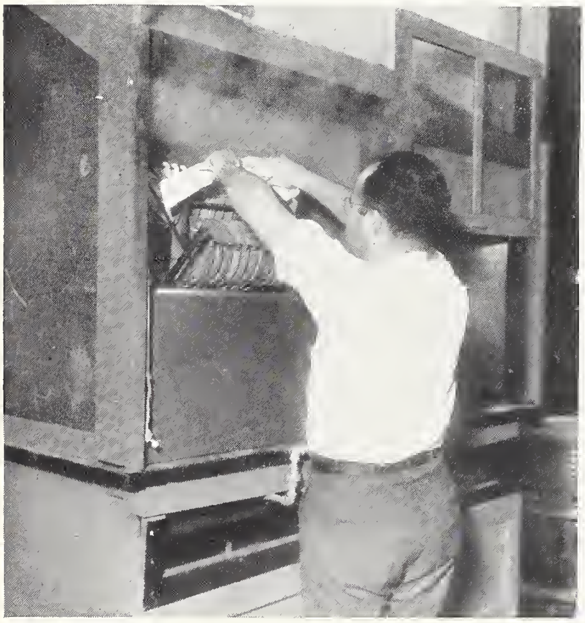

Figure 1.—*Steam cabinet used to produce the high humidity phase of the accelerated aging cycle for fiber building boards.*

II. TESTING FOR STABILITY

1. Accelerated Aging Treatment

Dry Heat was tried first as a means of accelerating the changes occurring during natural aging. Whereas heating 72 hours at 100° C (212° F) is often sufficient to make some papers and certain other fibrous materials brittle, practically no change in this respect was noted for the fiber building boards when heated for 150 hours at 100° C (212° F).

A high-humidity phase was added to find the effects of alternate wetting and drying. A cabinet was attached to a low-pressure steam line, and condensed steam at 90° to 95° C (194° F) allowed to fall on the test specimens for 6 hours daily, after which they were kept in a drying oven at 100° C for the remaining 18 hours. This cycle was repeated for a total of 300 hours. Some boards showed considerable loss in flexural strength. Low temperatures encountered in certain localities sometimes cause moisture to condense and freeze within walls. The freezing of water within fiber board may damage the board through the fibers being forced apart. Consequently, a freezing phase was added to the aging procedure. All further references to the effects of "accelerated aging" on the properties of the boards refer to the following aging cycle.

The test specimens are: Immersed in water at 50° C (122° F) for 1 hour; sprayed with condensed steam at 90° to 95° C (194° to 203° F) in the cabinet shown in figure 1; stored 20 hours at −12° C (10.4° F); heated 3 hours at 100° C (212° F) in dry air; again treated for 3 hours with condensed steam, then heated 18 hours at 100° C (212° F) in the oven shown in figure 2. This cycle of operations is repeated for a total of 300 hours during which time the specimens are exposed 40 hours to condensed steam, 130 hours to dry heat and 130 hours to freezing temperature. This procedure produces sufficiently large changes in the properties of the boards to permit classifying them into distinct groups.

Although the fiber boards are not, in general, designed for use as exterior finish, some are recommended for such use and the Bureau receives a large number of inquiries regarding their suitability for this purpose; hence, tests are in progress relative to this problem. The tests consist essentially of outdoor exposures, with water spraying at regular intervals to accelerate the normal aging. Painted and unpainted specimens, with edges sealed against moisture, are exposed in racks on the roof of the Industrial Building, as shown in figure 3. The exposure is for the duration of 1 year with periodical examination for changes in appearance, warping, and deterioration of surface finish.

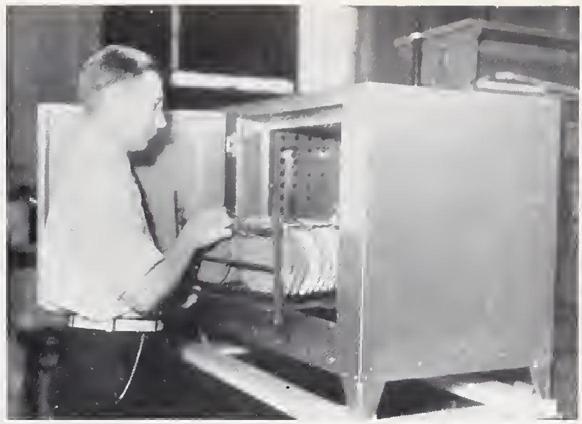

FIGURE 2.—*Drying oven used as a phase of the accelerated aging cycle for fiber building boards.*

2. Measurement of Aging Effects

The effects of aging are detected by determining the changes in strength, permeability to water and air, and chemical composition. The tests made are for flexural or transverse strength, nail-holding strength, water absorption, water penetration, permeability to air and water vapor, and cellulosic purity.

The flexural strength tests are made in accordance with the standard method described in a previous publication [4] and in a Federal Specification [5] for fiber building boards. This test is made by applying a load at midspan of a specimen 3 inches wide, laid flatwise on two parallel supports spaced 12 inches apart. The load is applied by means of a tensile testing machine, as shown in figure 4. The machine records the rupturing load and the deflection of the specimen at rupture. The flexural strength is an important property incident to the economical handling of the material, and the amount of loss may be considered as indicative of the extent of deterioration.

Any structural strength and rigidity imparted to a building by a fiber board is dependent, to some extent at least, on the nail-holding strength of the board. If during aging the board loses an appreciable part of this strength, its usefulness as a component part of the structure may be materially reduced. For measuring nail-holding strength, a method similar to one suggested by a manufacturer [6] was followed. This test measures the force required to move a 6-penny common wire nail to the edge of

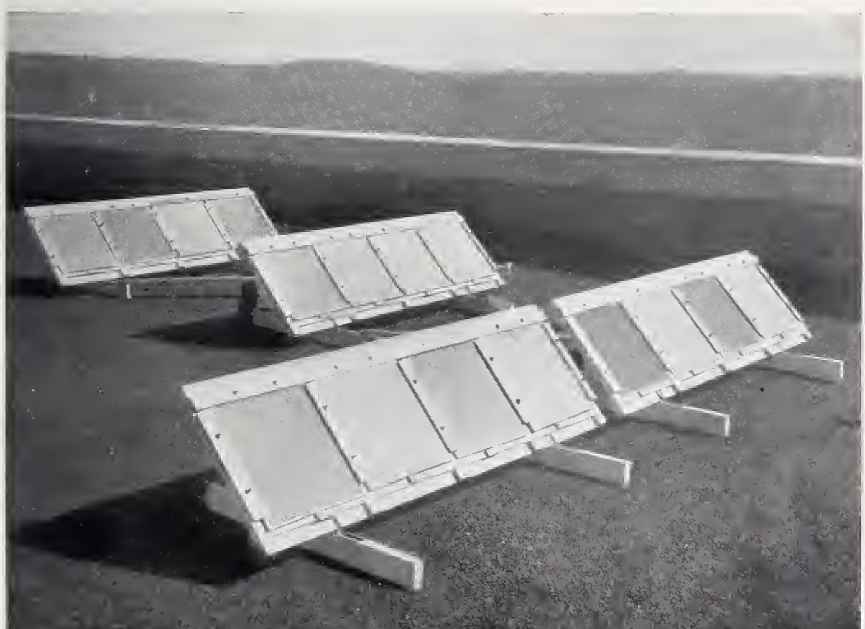

FIGURE 3.—*Roof exposures of painted and unpainted panels of fiber building boards.*

[4] Misc. Pub. BS 132 (1931).

[5] Fed. Spec. LLL-F-321a, Fiber Board; Insulating.

[6] This method was proposed by M. S. Wunderlich, of the Insulite Co.

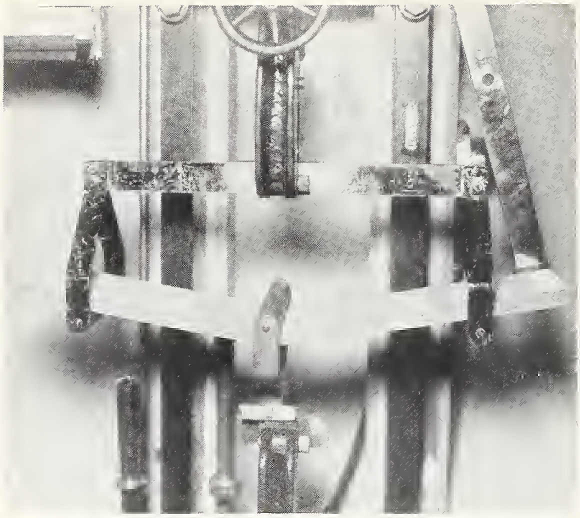

FIGURE 4.—*Flexural strength test.*

a board from a position ¾ inch from the edge. The test is illustrated in figure 5.

The existing method for determination of water absorption [7] was found to be suitable for use in this investigation. Specimens approximately 3 by 5 inches are weighed and immersed in water for 2 hours, removed and allowed to drain for 10 minutes, then reweighed. The increase in weight represents the amount of water absorbed and is expressed as percentage of the original volume.

The rate of water penetration through the boards is determined by the dry indicator [8, 9] method. An indicator consisting of a mixture of eosin dye and powdered sugar is sprinkled on one surface of the board and a glass cover is sealed over it to prevent moisture reaching the dye except through the board. The specimen with edges sealed by a wax coating is then floated on water. The time of transudation of water in a sufficient amount to develop color in the indicator is a measure of the relative water resistance. The test was developed for paper and paper products in general by F. T. Carson of the Bureau after he had found that numerous methods in use were unsound in one respect or another. The test is illustrated in figure 6.

Air permeability of fiber building boards is important in its relationship to the insulating value of the boards. The thermal insulation can be made less effective if heat is lost through the boards by infiltration of air. The measurement of air permeability serves also as a means of detecting changes in the structure of the material resulting from aging. The apparatus developed by F. T. Carson [10] is used for the determinations. This apparatus is illustrated in figure 7.

Investigations of the stability of writing papers have shown a close relationship between cellulosic purity and stability, papers with high alpha-cellulose content generally being more stable. It has been shown also that the alpha-cellulose content of paper is lowered by natural aging and by accelerated aging treatments, the amount of change being an indication of stability. The extent of chemical deteriora-

[7] Fed. Spec. LLL-F-321a, Fiber Board; Insulating.

[8] Paper Trade J. **98**, No. 21 (May 24, 1934).

[9] TAPPI Std. T433m, Tech. Assn. Pulp and Paper Ind. 122 E. 42d Street, New York, New York.

[10] BS J. Research **12**, 567 (1934) RP681.

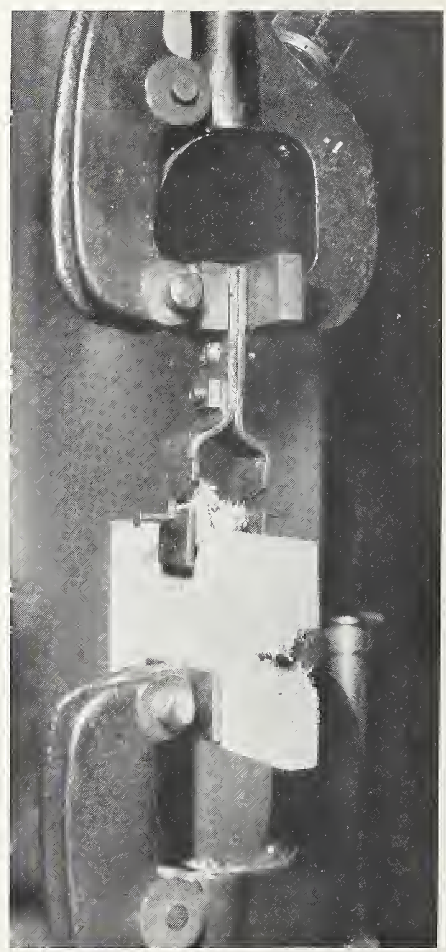

FIGURE 5.—*Nail-holding strength test.*

tion in boards, as indicated by decrease in alpha-cellulose content, is measured by use of the modified volumetric method [11] suggested by H. F. Launer of this Bureau.

3. Miscellaneous Exposures

Investigations have shown that light exerts a destructive influence upon textiles, paper, and other similar substances. Light from the carbon arc, as in the Weather-Ometer, has been used extensively in methods of accelerated aging. O. G. Strieter [12] recently found this type of exposure very satisfactory for determining the weathering quality of roofing materials, and it was investigated as an aging test for the fiber boards. Specimens were irradiated with light from the carbon arc and intermittently sprayed with water, the spray being shut off for 8 hours out of each 24 to allow the specimens to become thoroughly dry. The results of exposures up to 500 hours appeared to be principally surface effects. In view of this and since the boards are seldom, if ever, exposed unpainted to direct sunlight, the test was discontinued.

[11] J. Research NBS **20**, 87 (1938) RP1068.
[12] J. Research NBS **20**, 159 (1938) RP1073.

Figure 6.—*Water penetration test.*

Inasmuch as the presence of moisture within a wall during summer weather might be conducive to the growth of rot-producing fungi, a test is in progress to obtain data on any susceptibility of the boards to rotting. The method consists in inoculating specimens with three of the typical rot-producing fungi commonly found around wood construction, storing the specimens under warm, moist conditions favorable to the growth of the fungi, and observing the spread of the fungi and their effects on the boards. The selection of fungi was based on a recommendation of the Division of Forest Pathology, United States Department of Agriculture, and the cultures used were prepared in the Forest Pathology Laboratory. Inoculation was accomplished by placing pieces of culture approximately ½ inch square on these specimens. Each specimen was inoculated with cultures from all three fungi.

Figure 7.—*Air permeability test.*

III. RESULTS OF ACCELERATED AGING

While the Test Data for the extent of deterioration under the accelerated aging treatment are not yet complete, some typical results are shown in the accompanying charts. Losses in flexural

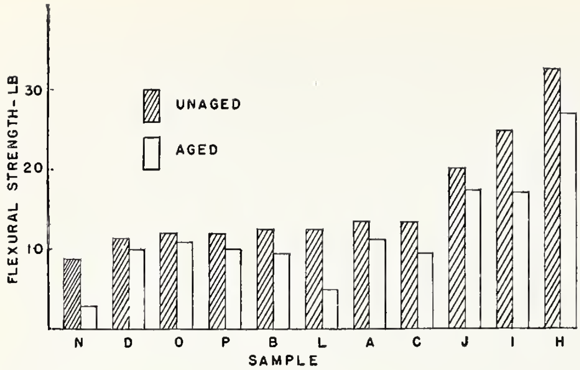

FIGURE 8.—*Effects of accelerated aging on the flexural strength of 11 fiber building boards.*

strength produced by accelerated aging are shown in figure 8. The scale to the left represents the strength in pounds. The shaded blocks are the values for unaged samples, and the unshaded blocks are values for samples which had been carried through the accelerated aging cycles for a total of 300 hours. Only two of these boards showed a serious loss in flexural strength, despite the severity of the aging treatment, the losses ranging from approximately 10 percent to about 60 percent.

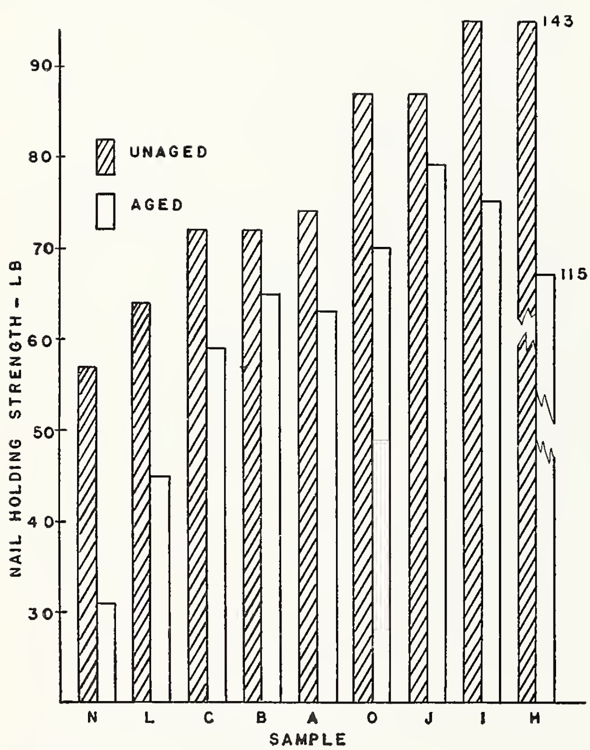

FIGURE 9.—*Effects of accelerated aging on the nail-holding strength of nine fiber building boards.*

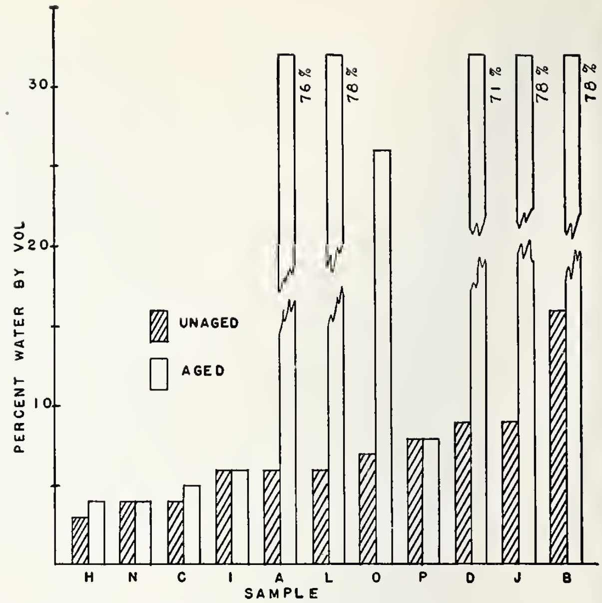

FIGURE 10.—*Effects of accelerated aging on the water absorption of 11 fiber building boards.*

The losses in nail-holding strength corresponded to the losses in flexural strength. Some results of the test are shown in figure 9. Here, serious losses in strength occurred in the two boards which were the weakest originally. For new boards, the force required averaged 57 pounds for the weakest board and 143 pounds for the strongest. After aging, the values were 31 and 115 pounds, respectively. In the test of the force required to pull the head of a common 6-penny wire nail through the board,

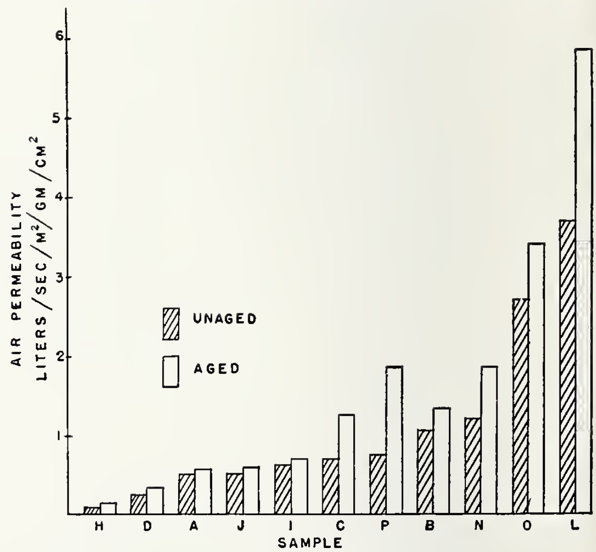

FIGURE 11.—*Effects of accelerated aging on the air permeability of 11 fiber building boards.*

the values ranged from 44 to 146 pounds. The values for the aged boards ranged from 19 to 127 pounds.

The effect of the aging procedure on absorption of water was quite marked for some boards, while others showed little change. Some results are shown graphically in figure 10 which presents values for water absorption before and after accelerated aging. Some boards showed increases in water absorption of several hundred percent. Corresponding changes in water penetration resulted from the accelerated aging. Some aged boards allowed water to penetrate in 1/200 the time required for the unaged board, while others showed no change on aging.

The changes in air permeabilities of the boards are a reflection of the internal structural changes produced by aging. Some results of this test are shown in figure 11. The vertical scale values show permeabilities expressed in liters of air passing through 1 m^2 of material a second, with a pressure difference of 1 g/cm^2.

Chemical analyses showed the alpha-cellulose content in aged boards to be from 2 to 6 percent less than for new boards. These losses are in line with those reported for the natural aging of paper, and suggest that the accelerated aging treatment produces changes comparable with those produced by natural aging.

IV. SUMMARY AND CONCLUSIONS

Accelerated Aging offers a convenient means of determining the stability of fiber building boards without the necessity of waiting years to observe the effects of natural aging. Data thus far obtained indicate that some of the boards have excellent stability, while others lose certain important properties rather rapidly under the accelerated test. The water resistance is the property that changes to the greatest extent in the boards which do not resist aging well, and this property may prove to be the most sensitive measure of the effects of aging.

Washington, June 14, 1938.

The *National Bureau of Standards* was established by act of Congress, approved March 3, 1901, continuing the duties of the old Office of Standard Weights and Measures of the United States Coast and Geodetic Survey. In addition, new scientific functions were assigned to the new Bureau. Originally under the Treasury Department, the Bureau was transferred in 1903 to the Department of Commerce and Labor (now the United States Department of Commerce). It is charged with the development, construction, custody, and maintenance of reference and working standards, and their intercomparison, improvement, and application in science, engineering, industry, and commerce.

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